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THE AGRICULTURAL LIMITS OF OUR POPULATION

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RECENTLY Pearl and Reed[1] have shown that growth of population in any country is expressed by a portion of the curve of a logarithmic parabola having the formula $y = \frac{be^{ax}}{1\text{-}ce^{ax}}$, where a, b and c have postitive values. In developing this law of population increase, the authors have been guided by true biological premises, and have made the first original contribution to the problem of population since the time of Malthus. The fit obtained when the records of the United States Census are applied to this curve is truly remarkable, as indeed are the fits of census figures of other countries; and any student of population hereafter who does not give careful attention to the conclusions they have drawn, is treating his subject in a superficial manner.

The particular point in this paper to be discussed here is the major asymptote of the curve as applied to our own country. This gives the ultimate population limit of continental United States as 197,000,000, a figure so much smaller than has usually been predicted that it has aroused much comment. Doubtless Pearl and Reed realize how hazardous it is to predict. One who makes a prediction after a careful study of a situation is immediately bombarded with impromptu criticisms submitted by those who have made no such study, but who feel that in their infinite wisdom they have immediately thought of numerous variables left out of consideration by those against whom their criticism is directed. Thus it will be said that errors in the census figures will change the end result, that methods of agriculture will improve radically, that standards of living will be simplified, that new methods of utilizing energy will be found, that synthetic foods will be produced, that any one of a hundred things will occur which will make it possible for a much greater number of persons to be enlisted under our star-spangled banner than Pearl and Reed find to be probable under existing tendencies. Such criticisms are especially likely to appear on the subject of population, for a great many persons seem to take it as a direct personal insult when one suggests either the advisability of a population limit as a factor in national welfare or the possibility of a population limit as the result of natural laws. To limit anything in the United States is blasphemy, though what the particular pleasure is in contemplating the country as an immense box of sardines, I am unable to discover. The authors would no doubt admit the possibility of certain changes in the present tendency for the population to increase. They would grant that for this reason the upper limits of our population are not to be set in 1920 with any high degree of accuracy. At the same time it could be shown, if space permitted, that criticisms of the type suggested above are not very cogent. They are the suggestions of the dilettante. The biologist realizes the improbability of new food products because of the fact that all our important foods were brought into use by prehistoric man. The geneticist is very conservative in his estimation of the prospects of a really great improvement in the domestic plants and animals. The chemist admits the possibility of synthetic foods as a laboratory stunt, but points out that as a practical scheme it is almost analogous to perpetual motion, since energy must be used up and man has never been able to approach nature in utilizing energy. The agriculturist points out the meagre changes in the art of agriculture which are the product of our civilization, and notes that those changes which have occurred are merely vehicles for exploiting a limited store of soil fertility at greater and greater speed. If there is any realm of activity wherein there is a small probability of radical future changes, it is agriculture; if there is any field wherein prediction for the future can be made from a study of the past with less likelihood of error, it is that in which agriculture is the major variant. Therefore a figure of 197,000,000 as the ultimate limit of population for the United States can not be cast aside for a *priori* reasons.

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[1] Pearl, R. and Reed., L. J. On the rate of growth of the population of the United States since 1790 and its mathematical representation. Proc. Nat. Acad. Sci. 6: 275-288. 1920.

What the writer proposes to do in this paper is to show that the agricultural possibilities in this country are not so great as they are generally supposed to be, and that even if these possibilities were to be fulfilled wholly the population the country could support is not enormously greater than the figures Pearl and Reed have set. And naturally one has no good reason for saying the upper limits of food production will be reached because of population pressure. It is to be presumed that Americans will have sufficient foresight to adjust the birth rate to the death rate and to attain a stationary population without the compelling force of grim necessity. We shall not discuss the possibilities latent in new food products, in better cultivated plants and domestic animals, or in new methods of agronomy. They have been considered carefully, and it is our opinion that they are not important factors in the matter.

In an essay on population published in a previous issue of this journal,[2] the writer showed what a comparatively small amount of reserve agricultural land still exists in the United States from which to produce food for our increasing population—a population which is rising by leaps and bounds. Unfortunately our reference to rapid population increase has been misunderstood in various quarters. This misunderstanding was caused by our calling attention to Pritchett's calculation of our future population based on the supposed fit of our census returns to part of the curve of a third order parabola. It was obvious from its shape that this curve had no biological basis, and the absurdity of expecting 386 million people in the year 2,000 and 1,113 million in the year 2,100 was pointed out. The figures were used merely to bring out the terrific rate of increase maintained at the present time, and to emphasize the efforts necessary to provide food if this increase were to be maintained. The amount of reserve agricultural land not now in farms proved to be about 35 per cent. of the present farm area. Since in the nature of the case this uncultivated land must be of poorer quality on the average than that which has been cultivated in previous years, we are warranted in assuming that even less than 35 per cent. of reserve land remains in this country when considered on a productivity basis. These calculations were made carefully and were sufficiently accurate for the purpose for which they were used, viz., to show how rapidly our population was encroaching on our potential food supply.

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[2] East, E. M. Population. Sci. Mon. 10: 603-624. 1919.

Since this paper was written a detailed study of the "Arable Land in the United States" has appeared under the authorship of O. E. Baker and H. M. Strong, of the United States Department of Agriculture, as one of the papers in the 1918 Yearbook issued in 1919. These authors have made an extremely valuable investigation of the agricultural lands of the United States, and support their conclusions with adequate data. We wish to point out some conclusions as to the possible ultimate population of the country with their figures as the basis. We venture to make only two slight changes. The first change is to withhold permanently from farm use an additional 50 million acres of potential improved land to provide space for future cities, roads and railroads. The second change is a reclassification of the land, which, because of its arid nature or because of its topography, can never be used for primary food production. Baker and Reed have classed only 38 million acres out of 653 million arid acres as desert having no grazing value. But as a matter of fact about 200 million acres more are desert lands where the grazing value is negligible.

The final disposition of the lands of the United States, then, may be expected to be somewhat like this: improved land, 800 million acres; forest and woodland 360 million acres; range land and unimproved pasture 415 million acres; desert 238 million acres; cities, roads and railroads 90 million acres. One thus accounts for the 1903 million acres making up the total land area of the country.

Those who cast a distrustful eye on the 1103 million acres, 58 per cent. of the total land area of the country, which are set apart as land which must be permanently withheld from cultivation, are referred to the arguments given *in extenso* by Baker and Strong. The reasons are plainly set forth in their paper, and if the writers err they err on the side of optimistic conservatism. Their figures may have to be revised at the end of a few centuries, but it is more likely that they will be revised upward than downward.

In brief, 743 million acres of these lands are set apart because of natural irremediable conditions. They consist of arid lands having no possibility of irrigation, lands where the mean summer temperature is too low to grow crops, lands where the topography is such that cultivation is impossible, lands which are without natural soil fertility, and undrainable swamps. Nevertheless such lands, when the population pressure becomes sufficiently great, may be used to produce some food. The cheerful optimist, and we shall take on that rôle for the time being, may perhaps assume that there is the possibility of supporting one person per each 100 acres upon them—a total of 4 million people.

The 360 million acres of forest and woodland must be retained for a variety of reasons. In most cases their topography prevents their cultivation, so that they could not be used for farm lands even if no other obstacles intervened. But beyond this fact stands the opinion of meteorologists, that if this figure for a forest reserve be cut, a change in the rainfall and the temperature of the improved land would ensue such as to reduce its productivity much beyond that of any increased production resulting from the additional new lands. On the other hand, there remains the possibility of producing considerable amounts of both primary and secondary foods on these reserves without destroying their usefulness as forests and woodlands. When food becomes sufficiently scarce and the price in consequence becomes sufficiently high, these lands will be utilized. They will perhaps produce sufficient food to support one person for each 50 acres, giving an additional potential population of a little over 7 millions.

There remains, then, a potential 800 million acres of improved land for consideration. This figure is made up by adding together the 478 million acres in cultivation in 1910, 30 million acres of desert land which irrigation engineers believe may be irrigated, 60 million acres of swamps that can be drained, 82 million acres suitable for dry farming and upland pasture, and 200 million acres of tillable land which is now in woodland. The sum obtained is 850 million acres. But from this sum must be subtracted a parcel of 50 million acres to allow for the growth of cities, roads and railroads. 800 million acres of arable land are left. The question then arises; what potential population will this land support? It is a question that can be answered in a rough way by comparing the per capita acreage of cultivated land in foreign countries as compiled by the International Institute of Agriculture at Rome.

Before the war Germany cultivated 48 per cent. of her land area, France cultivated 45 per cent, Italy cultivated 48 per cent, and Belgium 49 per cent. It will be seen that these figures are fairly comparable with the 42 per cent. proposed for the United States as the sum total of her arable possibilities. Furthermore our comparison is fair in a historical sense, since these countries were over-populated as shown by the fact that they did not live within themselves agriculturally, and since our own country is made up of peoples from similar racial stocks and therefore may be presumed to have similar tastes, customs and abilities.

On the face of the returns, these countries were tilling the following number of acres per capita; Germany 1.15 acres, France 1.5 acres, Italy .98 acres, Belgium .57 acres. These figures, however, do not show the true state of affairs. For example, the total arable land of Belgium can not be compared with that of the United States. It is much too good. It is no more right to use her wonderful bottom lands as a standard than it would be to use the Nile overflow lands of Egypt where nature robs Peter to pay Paul and produces greater crops than anywhere else in the world. It is no more proper than to expect all the soils of the United States to come up to the production figures of the Mississippi Valley. Exclude Belgium and a fair comparison can probably be made if one is careful to make the comparison fair. These countries were not self supporting. Huge quantities of food were imported annually. We have not been able to obtain the complete returns for exports and imports from which to make an accurate accounting of the number of people actually supported per acre in such countries as France and Germany where both the standard of living and the efficiency of the agriculture is high. In Germany it seems to have been pretty close to 2.2 acres per man when all corrections are made. In France it was probably somewhat higher. Personally I believe that 2.5 acres per man is the limit that we may hope to reach in the United States if we cultivate our whole 800 million acres, if we keep up a reasonable standard of living, if we follow rather closely our present food habits, if we conserve carefully our soil fertility, and above all if we farm as intensively, as scientifically and with as little waste as the best farmers of Europe who have been under the necessity of perfecting their agriculture because of population pressure during the past half-century.

If this assumption be true, our 800 million arable acres will support 320 million people, a figure to be added to the 11 millions obtained by calculating the productivity of our grazing lands and forests. The maximum population the United States can support under any conditions conceivable to those of us who live at the present day, therefore, is 331 millions.

To be sure 331 millions of people is a right tidy little population. China is supposed to have about 300 millions, with a land area 600 million acres greater than the United States. Can we wish to be placed ultimately in an economic position less favorable than that of present day China? We should all answer, No! Is it, then, improbable that we shall use a little forethought before this time comes, and establish a birth rate adjusted to the death rate which will withold from us the economic pressure which she confronts at all times? If this be reasonable, is it not probable that Pearl and Reed's figures of 197 million, as the upper limit of the population that the United States will actually attain, are wholly just and proper?

The most optimistic of our population enthusiasts will criticize these figures no doubt. They will point at once to Japan as the shining example of efficient agriculture, an example that we ought to hold ever before us and strive to emulate. Japan, with a population of 52 millions in 1911, cultivated 18 million acres out of a total land area of 94 million acres. By an extraordinary use of fertilizers, which reached a figure of over 4.5 tons per acre over the whole cultivated area, exclusive of commercial chemicals, she was thus able to support 3 persons per acre. In reality the figures reported should not be quite so high, as Japan imported a very much larger amount of foodstuffs than she exported in the years just previous to the war. But with due allowance for imports Japan did actually produce food sufficient to support about 2.5 persons per acre of cultivated land. If the United States could do as well on her 800 million acres of arable land, our population might have a maximum limit of 2000 millions—a figure greater than the present population of the world.

Let us stop a moment and do a little more figuring before we accept this computation. The Japanese are small. Their army rations are only about one-half of ours. Their population as a whole gets along with less than half of the food per capita required by the people of the United States. Undoubtedly our own people are great wastrels because they have more to waste, and could get along with less if it were necessary; but it may be questioned whether Japan's crops would support more than 1.5 Americans per acre, even with a material lowering of the standard of living and a higher standard of efficiency for food utilization. Naturally it will be maintained by some that this difference in food consumption between the American nation and the Japanese nation is unnecessary. It will be pointed out that excess of body weight in one over the other is not over 25 per cent., and that for this reason a 25 per cent. difference in food production is all that can reasonably be demanded. But this is not the whole truth in the matter. Food habits are very ancient. Pearl has shown that the people of the United States did not reduce their food intake during the war though there was an urgent moral necessity that this should be done. Nevertheless during this period the people not only ate just as much, they even demanded their food in whatever expensive forms appealed to their tastes. Our contention is, therefore, that while a constant economic pressure maintained over long periods may modify our food habits, it will be just as difficult for us to cut our present ration as for the Japanese to cut the one to which they have become accustomed. And it does not appear that such established folkways will be materially modified in the comparatively short length of time which present indications allow us as the interval before we reach a close approximation of our population limit—i. e., the point where our population curve turns sharply toward the horizontal.

There is still another important modification of our computation to be made. We have an extensive system of agriculture in this country. Our yields per acre are comparatively low; but we farm more land per man than any other country. The Belgian, the most intensive farmer of Northern Europe, for example, cultivated 5 acres per man before the war; the comparative figure for the United States is 26 acres. Now we have calculated that the United States contains 800 million acres of arable land that can ultimately be put under the plow, but if we suppose that this 42 per cent. of the whole land area of the country can be made to produce the crops which Japan produces on 18.7 per cent. of her area we are making a grave mistake.

Japan cultivates a comparatively small proportion of her land area by a method built up in China, because she has found that she thus gets the greatest returns. She even goes so far in her conservation and utilization of soil fertility as to strip the surface soil from less productive areas for use upon her best land. Indeed it is wholly probable, as may be seen by a study of the relief maps of the two countries, that Japan has almost as high a percentage of arable land as the United States. But she has found that it does not pay to try to cultivate it all. We have considerable reason for supposing that Japan would not obtain a significant increase in her total production of foods if she cultivated 42 per cent. of her area instead of 18.7. If, therefore, her productiveness were measured in relation to the first percentage (42), she really would need 1.5 acres per man to support her population in terms of American food habits. At this rate, the United States could support only 530 millions on her arable land. Presumably this figure may be taken as the ultimate limit humanly possible for the country. That we shall ever reach this figure seems to the writer wholly absurd.